CLAIMS

What is claimed is:

1. A method used in locating a mobile transmitter for improving a time difference of arrival (TDOA) estimate produced by cross-correlating a reference signal with a cooperating signal, using either a time-domain cross-correlation or frequency-domain cross-spectrum process, wherein the reference signal is a copy of a first signal transmitted by the mobile transmitter as received at a first antenna and the cooperating signal is a copy of the first signal transmitted by the mobile transmitter as received at a second antenna, comprising the steps of:
   a. determining a most likely range of TDOA estimates;
   b. searching the cross-correlation results only within the most likely range of TDOA estimates; and
   c. estimating the TDOA to be the value within the most likely range that is associated with an optimal value of the magnitude of the cross-correlation.

2. A method as recited in claim 1, wherein the most likely range of TDOA estimates is limited to time values associated with the distance between the first antenna at which the reference signal was received and the second antenna at which the cooperating signal was received, plus a predetermined error value.

3. A method as recited in claim 1, wherein the most likely range of TDOA estimates is determined as corresponding to only an area in which the mobile transmitter is *a priori* known to be located.

4. A method as recited in claim 1, wherein the optimal value is the highest magnitude peak of the time-domain cross-correlation or equivalent frequency-domain cross-spectrum process.

5. A method as recited in claim 1, wherein the optimal value is the earliest point in time when the magnitude of the time-domain cross-correlation or equivalent

frequency-domain cross spectrum process is no less than a predetermined proportion of the highest magnitude peak of the time-domain cross-correlation or equivalent frequency-domain cross-spectrum process.

6. A method as recited in claim 1, wherein the optimal value is the earliest point in time when the magnitude of the time-domain cross-correlation or equivalent frequency-domain cross-spectrum process is no less than a predetermined proportion of the average noise level.

7. A method as recited in claim 1, wherein the mostly like range of TDOA estimates is further limited so as to correspond to an area within a predetermined distance from the first antenna receiving the reference signal.

8. A method as recited in claim 1, wherein the mostly like range of TDOA estimates is further limited so as to correspond to an area within a predetermined distance from the second antenna receiving the cooperating signal.

9. A method as recited in claims 7 or 8, wherein the predetermined distance is determined using a round trip delay measurement.

10. A method as recited in claims 7 or 8, wherein the predetermined distance is determined by measuring the received power of the mobile phone at the first and second antennas.

11. A method used in locating a mobile transmitter for improving a time difference of arrival (TDOA) estimate produced by cross-correlating a reference signal with a cooperating signal, using either a time-domain cross-correlation or equivalent frequency-domain cross-spectrum process, wherein either process requires the simultaneous solution of both frequency difference of arrival (FDOA) and TDOA, wherein the reference signal is a copy of a first signal transmitted by the mobile transmitter as received at a first antenna and the cooperating signal is a copy of the

first signal transmitted by the mobile transmitter as received at a second antenna, comprising the steps of:

a. determining a most likely range of FDOA estimates;
b. determining a most likely range of TDOA estimates;
c. searching the cross-correlation results only within the most likely range of TDOA and FDOA estimates;
d. estimating the TDOA to be the value within the most likely range that is associated with an optimal value of the magnitude of the cross-correlation.

12. A method as recited in claim 11, wherein the most likely range of FDOA estimates is limited to the frequency values associated with a stationary or nearly stationary mobile transmitter.

13. A method as recited in claims 11 and 12, wherein the most likely range of TDOA estimates is limited to time values associated with the distance between the first antenna at which the reference signal was received and the second antenna at which the cooperating signal was received, plus a predetermined error value.

14. A method as recited in claims 11 and 12, wherein the optimal value is the highest magnitude peak of the time-domain cross-correlation or equivalent frequency-domain cross spectrum process.

15. A method as recited in claims 11 and 12, wherein the optimal value is the earliest point in time when the magnitude of the time-domain cross-correlation or equivalent frequency-domain cross spectrum process is no less than a predetermined proportion of the highest magnitude peak of the time-domain cross-correlation or equivalent frequency-domain cross spectrum process.

16. A method as recited in claims 11 and 12, wherein the optimal value is the earliest point in time when the magnitude of the time-domain cross-correlation or

equivalent frequency-domain cross spectrum process is no less than a predetermined proportion of the average noise level.

17. A method as recited in claim 12, wherein the mostly like range of TDOA estimates is further limited so as to correspond to an area within a predetermined distance from the first antenna receiving the reference signal.

18. A method as recited in claim 12, wherein the mostly like range of TDOA estimates is further limited so as to correspond to an area within a predetermined distance from the second antenna receiving the cooperating signal.

19. A method as recited in claims 17 or 18, wherein the predetermined distance is determined using a round trip delay measurement.

20. A method as recited in claims 17 or 18, wherein the predetermined distance is determined by measuring the received power of the mobile phone at the first and second antennas.

21. A method used in locating a mobile transmitter, comprising:
    a. providing a set of cross-correlation values, wherein each cross-correlation value is associated with a corresponding TDOA and/or FDOA estimate and is produced by cross-correlating a reference signal with a cooperating signal, the reference signal comprising a copy of a signal transmitted by the mobile transmitter as received at a first antenna and the cooperating signal comprising a copy of the signal transmitted by the mobile transmitter as received at a second antenna;
    b. determining a most likely range of TDOA and/or FDOA estimates;
    c. identifying an optimal cross-correlation value within a subset of cross-correlation values corresponding to the most likely range of TDOA and/or FDOA estimates; and

d. employing the TDOA and/or FDOA value corresponding to the optimal cross-correlation value in calculating the location of the mobile transmitter.

22. A method as recited in claim 21, wherein the cross-correlating comprises cross-correlating in the time-domain.

23. A method as recited in claim 21, wherein the cross-correlating comprises cross-correlating in the frequency-domain.

24. A method as recited in claim 21, wherein the most likely range of TDOA estimates is based upon a rough estimate of the location of the mobile transmitter.

25. A method as recited in claim 21, wherein the most likely range of FDOA estimates is based upon a rough estimate of the speed of the mobile transmitter.

26. A method as recited in claim 24, wherein the rough estimate is based at least in part on the distance between the first and second antennas.

27. A method as recited in claim 26, wherein the rough estimate is further based on a predetermined error value.

28. A method as recited in claim 24, wherein the rough estimate is based on an area in which the mobile transmitter is *a priori* known to be located.

29. A method as recited in claim 21, wherein the cross-correlation value having the largest peak magnitude within said subset of cross-correlation values is identified as the optimal cross-correlation value.

30. A method as recited in claim 21, comprising identifying, as the optimal cross-correlation value, the value within said subset of cross-correlation values having

the smallest associated TDOA estimate for which the magnitude is no less than a predetermined proportion of the largest peak magnitude.

31. A method as recited in claim 21, comprising identifying, as the optimal cross-correlation value, the value within said subset of cross-correlation values having the smallest associated TDOA estimate for which the magnitude is no less than a predetermined proportion of an average noise level.

32. A method as recited in claim 24, wherein the rough estimate is based on an area within a predetermined distance from the first antenna.

33. A method as recited in claim 24, wherein the rough estimate is based on an area within a predetermined distance from the second antenna.

34. A method as recited in claims 32 or 33, wherein the predetermined distance is determined using a round trip delay measurement.

35. A method as recited in claims 32 or 33, wherein the predetermined distance is determined by measuring the received power of the mobile transmitter at the first and second antennas.

36. A Wireless Location System (WLS) for locating a mobile transmitter, comprising:
    a. means for determining a most likely range of TDOA and/or FDOA estimates; and
    b. means for identifying an optimal cross-correlation value within a subset of cross-correlation values corresponding to the most likely range of TDOA and/or FDOA estimates, said subset of cross-correlation values being contained within a set of cross-correlation values, wherein each cross-correlation value in the set is associated with a corresponding TDOA and/or FDOA estimate.

37. A system as recited in claim 36, wherein each value in said set of cross-correlation values and is representative of a cross-correlation, in the time or frequency domain, of a reference signal with a cooperating signal.

38. A system as recited in claim 37, wherein the reference signal comprises a copy of a signal transmitted by the mobile transmitter as received at a first antenna and the cooperating signal comprises a copy of the signal transmitted by the mobile transmitter as received at a second antenna.

39. A system as recited in claim 36, further comprising means for employing the TDOA and/or FDOA value corresponding to the optimal cross-correlation value in calculating the location of the mobile transmitter.

40. A method for use in a Wireless Location System (WLS) for locating a mobile transmitter, comprising:

a. determining a most likely range of TDOA and/or FDOA estimates; and
b. identifying an optimal cross-correlation value within a subset of cross-correlation values corresponding to the most likely range of TDOA and/or FDOA estimates, said subset of cross-correlation values being contained within a set of cross-correlation values, wherein each cross-correlation value in the set is associated with a corresponding TDOA and/or FDOA estimate.

41. A method as recited in claim 40, wherein each value in said set of cross-correlation values and is representative of a cross-correlation, in the time or frequency domain, of a reference signal with a cooperating signal.

42. A system as recited in claim 41, wherein the reference signal comprises a copy of a signal transmitted by the mobile transmitter as received at a first antenna and the cooperating signal comprises a copy of the signal transmitted by the mobile transmitter as received at a second antenna.

43. A system as recited in claim 40, further comprising employing the TDOA and/or FDOA value corresponding to the optimal cross-correlation value in calculating the location of the mobile transmitter.